A COMPARISON OF TRANSPORT COSTS, PHYSICAL PERFORMANCE, AND SPOILAGE FACTORS FOR INTERMODAL SHIPMENTS OF ICEBERG LETTUCE TO EUROPEAN MARKETS

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PREFACE

This study is one of a series by the Agricultural Research Service to find ways of shipping U.S. agricultural products to overseas markets in a better condition and at a lower cost. The Office of Subsistence Policy and Management of the Assistant Secretary of Defense for Installation and Logistics initiated a request to USDA's Agricultural Research Service, Transportation and Packaging Research Laboratory, for a cooperative study. The series of field tests would either confirm or deny that the high lettuce spoilage and associated costs being experienced could be reduced sufficiently to offset the increased costs of air transportation.

Although these studies were made in 1970 and 1972, the results are still valid and useful as guidelines for developing similar cost and input data in related transport analysis. The representative costs have been updated to reflect 1976 transport costs and to show differences between air cargo and surface (van container) transports. Publication is deemed necessary to make these results available to the cooperator (U.S. Department of Defense) and others who seek less expensive and most effective ways of shipping iceberg lettuce to European markets.

ACKNOWLEDGMENTS

The research was made possible through the efforts and contributions of numerous individuals and organizations. Valuable assistance and support for the work were received from the Department of the Army, the Defense Personnel Support Centers (DPSC) at Philadelphia, Pa., and Alameda, Calif., and the Defense Supply Agency at Cameron Station, Va. Many lettuce shippers and carriers made their products, facilities, and equipment available.

Assistance in developing and implementing the study was generously given by George Pawl and Robert Bennett of the DPSC at Philadelphia and Colonel R. Stone and Harold Beals of the DPSC at Alameda. Emerson Allen of the Department of the Army was the Action Officer for the project and provided the necessary collaboration between the U.S. Department of Defense units and the U.S. Department of Agriculture.

Robert T. Hinsch and Roger Rij, Agricultural Research Service (ARS) researchers in Fresno, Calif., assisted in initiating the tests at origin. Russell Hinds, Jr., William Chace, Jr., and Lawrence Risse of the ARS European Research Unit in Rotterdam, The Netherlands, collected the destination data. William Black, ARS, Beltsville, Md., also assisted in the study. The study was made under the immediate supervision of D. L. Anderson and P. L. Breakiron, ARS.

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A COMPARISON OF TRANSPORT COSTS, PHYSICAL PERFORMANCE, AND SPOILAGE FACTORS FOR INTERMODAL SHIPMENTS OF ICEBERG LETTUCE TO EUROPEAN MARKETS

By C. J. Nicholas 1/

SUMMARY

Agricultural Research Service researchers at the request of and in cooperation with the Defense Supply Agency of the U.S. Department of Defense conducted studies in 1970 and 1972 on the handling and transport problems for shipping iceberg lettuce to U.S. Army commissaries in Europe. Representative transport costs were updated in 1976.

The study identifies some of the problems and opportunities of air cargo and surface (van container) shipments. Cost comparisons are made between these two transport modes. Also, the cost effectiveness of air cargo transport is weighed.

Physical performance factors showed that because good iceberg lettuce can be shipped by surface (van container) transport to European markets in good condition and at a reasonable cost, air cargo transport is warranted only when an emergency resupply situation exists. Also, the use of the bonded-block pattern was adequate if it was combined with such improved practices as precooling of lettuce to desirable temperatures before loading, harvesting and packaging in the field, and accurate scheduling to prevent delays and layovers at terminals and in transit.

Current transport technology is adequate for surface transport of lettuce to European destinations in good condition and at a reasonable cost. Also, successful shipping of lettuce to European markets depends not only on the transport equipment but also on how the transport equipment is handled and to what use this equipment is put. The outturn of the experimental test shipments was excellent when the following conditions were met: (1) The quality of the product was good at time of shipment, (2) the refrigeration unit operated properly, (3) the thermostat was accurately calibrated, (4) the shipment was loaded in a van container in a bonded-block pattern, and (5) the product was not roughly handled in loading and unloading.

The cost differential of 10 cents a pound between air and surface transport and average spoilage losses of 5 to 6 percent by surface transport during a 6-month test period confirmed the cost effectiveness of containerized

1/ Agricultural economist, Transportation and Packaging Research Laboratory, Northeastern Region, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Md. 20705.

surface transport for the movement of lettuce to European markets. This proved that air transport was warranted only in emergencies.

The intermodal transport of lettuce by van container is the best method for shipping U.S.-produced lettuce to European markets in good condition and at a reasonable cost. Loading lettuce in van containers at the shipping point, moving them to the port of embarkation by the fastest transport mode at the lowest cost, and expediting the movement of these van containers from the overseas port to the receiver eliminate some major transport problems.

INTRODUCTION

Iceberg lettuce, one of the most perishable vegetables exported from the United States, requires prompt cooling, suitable intransit temperatures, and careful handling to prevent deterioration.

Significant improvements have been made recently in packaging, refrigeration, and handling; however, high spoilage losses are still common for lettuce shipped overseas. Commercial shipments of lettuce to Europe have had disappointing results. Less than 1 percent of iceberg lettuce produced in the United States is exported to European markets, partly because of high transportation cost, the long transit times, and the high perishability of lettuce. However, because of the preference for this lettuce by U.S. troops stationed abroad, U.S. tourists, and a gradual change in the eating habits of the Europeans, the market for iceberg lettuce is increasing.

Attempts to grow iceberg lettuce in Spain, The Netherlands, Sweden, and North Africa may prove successful, in which case these countries will be able to capture some of the European market for iceberg lettuce. If American lettuce growers are to compete effectively, transportation to these markets must be improved so that lettuce can be delivered overseas in good condition and at lower costs.

The U.S. Department of Agriculture (USDA), aware of the problems in the transport of iceberg lettuce for many years, has been working with commercial growers. Also, the USDA has in the past assisted the Defense Supply Agency (DSA) in research to evaluate and improve the shipment of agricultural perishables to overseas destinations. This cooperation was mutually beneficial to both organizations.

The experience of the military shipper in the overseas movement of lettuce has been disappointing. To reduce these losses, more reliance recently has been put on air transport. While air transport reduces spoilage losses, it also increases the total laid-down cost of the lettuce at overseas points. Therefore, DSA, whose responsibility includes military subsistence, has been trying to determine the cost effectiveness of air or surface transport, the total cost difference, and the spoilage rate of lettuce.

Some of the problems and advantages in using surface van container transport are identified. Furthermore, cost comparisons between air cargo and surface transport and the cost effectiveness of air transport are weighed.

The physical (transit time and temperature) performance, transport charges of the surface (van container), and air cargo modes used in moving lettuce from the fields in New York and California (1970) and in California (1972) to the receivers in West Germany are evaluated. Comparisons were made in paired shipments--one experimental air shipment and one surface (van container) shipment from the same origin to the same destination at the same time.

The cost comparisons serve to identify the differences and cost advantages of the two transport modes, not only the total cost of each mode but how these total costs were distributed among the different handling steps and transport modes.

Although the data were collected in 1970 and 1972, the methodology is still valid and can be used as guidelines for developing similar cost and input data in related transport analysis. The cost data for the particular shipments covered by this report are sufficiently representative of the two transport modes. The representative nature of these cost data has been updated to reflect 1976 transport costs and to show differences between the two transport modes.

MATERIALS AND METHODS

Lettuce grown in the Salinas, Calif., area was mechanically handled (cut, trimmed, wrapped, and boxed) in the field; while that in the Oswego, N.Y., area was manually handled. There were 7 separate mechanical handlings in 1970 and 10 in 1972 and 9 separate manual handlings in 1970 from harvesting to shipping.

Mechanical Handling

All of the lettuce bought from the same grower, originating in the Salinas, Calif., area during the 1970 and 1972 tests, was mechanically handled. The grower at harvest packaged the lettuce in the field by using a large mobile packing platform which carried both the wrappers and the packers (fig. 1). The number of lettuce boxes in the tests varied according to the containers used--150 boxes were used in the air cargo containers, 500 boxes in the 35-foot van containers in 1970, and 800 boxes in truck shipments from growing areas in California to the ports of embarkation. Six hundred and fifty-eight lettuce boxes were loaded into 40-foot van containers in 1972 where a 5 by 3 load pattern was used. Some 40-foot van containers with greater inside dimensions permitted a 5 by 4 block load pattern making possible a load of 676 cartons.

The mobile packing platform manned by a crew of 31 had a set of roller conveyors mounted on a truck chassis with 4 axles and 8-wheel drive.

Figure 1.--Field operation used to harvest lettuce in Calif.

The crew consisted of the following:

- A foreman
- A crewman who made up the wax-impregnated boxes made of 350-pound bursting strength corrugated fiberboard
- 13 crewmen who cut and trimmed the lettuce and placed it on the roller conveyor
- 9 crewmen who wrapped the lettuce in polystyrene film as the lettuce proceeded on the roller conveyor
- 5 crewmen who filled the waxed boxes with 24 heads of lettuce
- 2 crewmen who glued and stapled the boxes and set them off in the field

The output of the machine crew varied from 150 to 170 boxes of wrapped lettuce per hour. After the lettuce was boxed and loaded on pallets, a 20-foot flatbed truck with ½ cab transported the shipment a distance of 3 miles to the vacuum cooler. There the boxes were unloaded onto two 4- by 10-foot metal pallet racks. A specially made gasoline-driven forklift truck, with 10 forks, then placed the pallets in front of the vacuum cooler where at 30-minute intervals they were placed into and removed from the cooler.

The vacuum cooler crew consisted of the operator, a high-lift operator, a "push back," two loaders, and a set-off man.

After vacuum cooling, the load proceeded on a conveyor belt from the vacuum cooler to the outloading dock (fig. 2). With the conveyor setting the pace, the four loaders received the boxes from the roller conveyor and placed them in a 35-foot unit van container.

In the 1970 California shipments, there were seven separate handlings of the lettuce source-loaded in the field. By wrapping and boxing the lettuce in the field and loading the van container at the harvest area, three additional handlings were eliminated, thus reducing chances for box damage and lettuce bruising.

In the 1972 California test the lettuce shipments were subjected to 10 separate handlings from harvest to transport even though the lettuce was source-loaded in the field. Because refrigerated van containers were in short supply, the carriers could not provide them for loading in the harvest areas. Therefore, after the lettuce was harvested, wrapped, boxed, and vacuum-cooled (which required seven handlings), the boxes were loaded immediately into a refrigerated trailer truck for transport to Cheathem Annex, Va. Thus, the lettuce boxes were subjected to three additional handlings at Cheathem Annex before they were loaded into the van container.

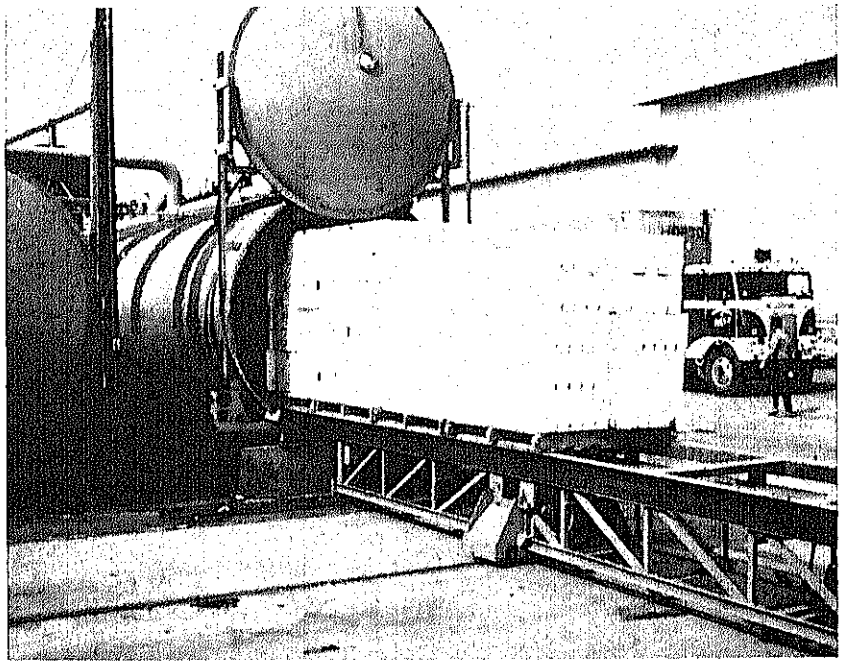

Figure 2.--Lettuce boxes unloaded from vacuum cooler, placed on a roller conveyor for transport to outloading dock.

Manual Handling

All of the lettuce originating in the Oswego, N.Y., area was handled manually in the 1970 tests. There was no uniformity in the handling procedures. ARS researchers accompanied the trimmers, wrappers, and packers who worked in field sheds near the harvest areas. The harvesting crew consisted of seven laborers--three cutters, two box packers, a sprayer 2/, and a box stapler.

The carry-off operation from the field required six men and a flatbed truck. The packing-plant operation maintained a continuous labor force of approximately 22 people: 10 trimmers, 6 wrappers who placed lettuce heads in the cellophane bags, 3 packers who repacked the lettuce in the original boxes, 2 staplers who restapled the boxes, and 1 person who used a hand truck to move the lettuce boxes to the staging area.

Because the insulation of the van containers could not withstand the low pressures of the vacuum cooler, they were loaded after the lettuce was vacuum-cooled. Thus, nine separate handlings were required from the time the lettuce was harvested until it was loaded into the van container for transport to the port. At least two, and possibly three, handlings could have been eliminated had the trimming and wrapping been accomplished in the field instead of at the packing shed.

Loading

The 1970 test shipments, six paired air and surface, originated in Oswego, N.Y., and Salinas, Calif. In air shipments, 150 boxes of lettuce were source-loaded into refrigerated trailer trucks that transported them to the John F. Kennedy and San Francisco airports, respectively. There the boxes were transloaded into Type A-2 igloos 3/ (fig. 3A), which were kept in a cold room until departure time. A forklift truck, a motorized dolly, and a motorized elevator loaded the containers from the cooling room into the aircraft. In surface shipments 500 boxes of lettuce were source-loaded into van containers, which were hauled by a 35-foot refrigerated trailer truck to the New York area. The containers were then put aboard containerships at Port Elizabeth, N.J.

The 1972 test shipments, six paired air and surface, all originated in California. In air shipments all handling procedures were the same as in 1970 except the boxes were transloaded into LD-3 4/ (fig. 3B) instead of Type A-2 igloos. In surface shipments, because van containers were in short supply, boxes of lettuce were source-loaded into 40-foot refrigerated trailer trucks and trucked to Cheathem Annex, Va. The boxes were transloaded into van containers which were transported to Norfolk, Va., and loaded aboard containerships.

2/ One who sprays lettuce with water to prevent dehydration during vacuum cooling.

3/ An air freight container loading unit, consisting of a platform and folding hood shaped to the aircraft's configuration.

4/ Aluminum cargo containers contoured to fit the airplane cabin interior of a Boeing 747 airplane.

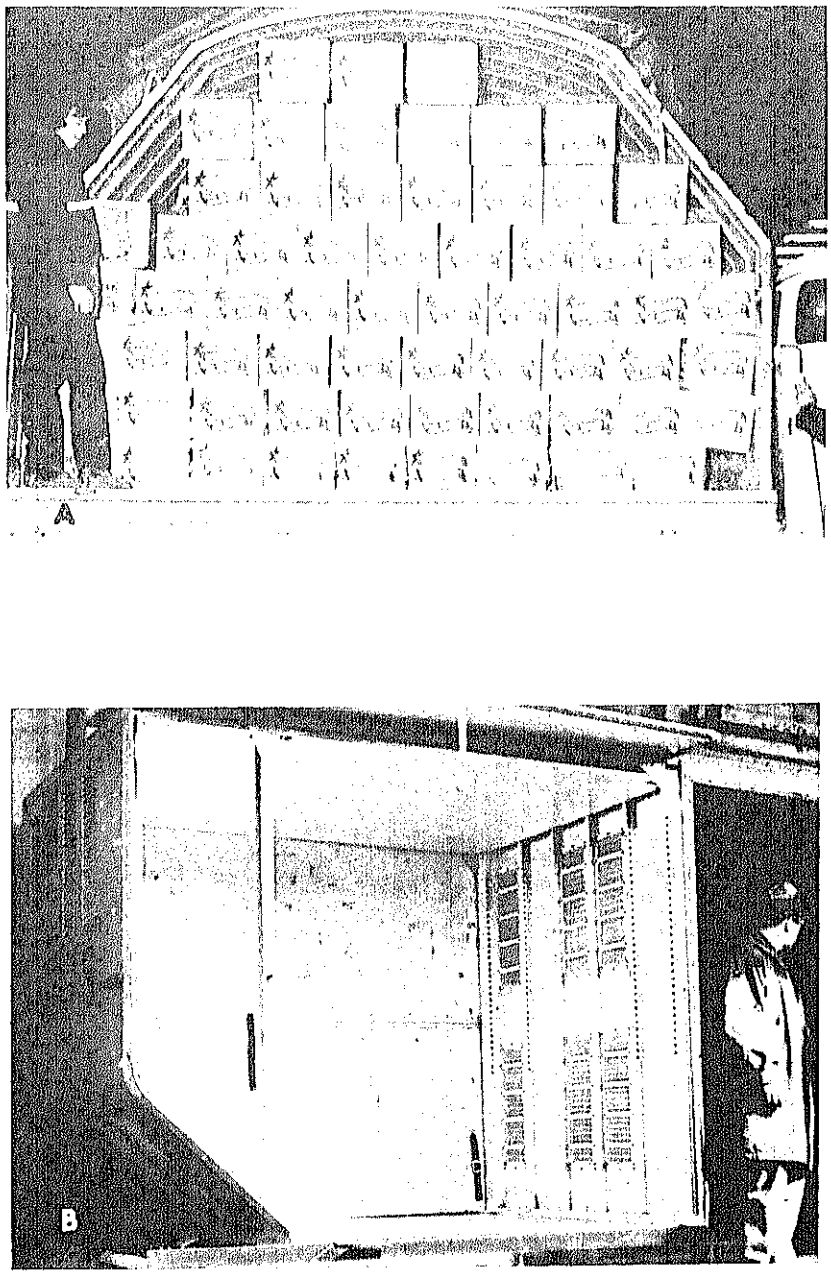

Figure 3.--Air cargo containers used in shipping lettuce: *A*, Type A-2 igloo, 10,000 lb maximum gross weight, actual pound tare weight, and 450 ft^3 usable volume; *B*, LD-3, 2,500 lb (1,134 k) maximum payload, 370 lb (168 k) tare weight, and 153 ft^3 (4.33 m^3).

Unloading

At the overseas airport, the same type of mechanized equipment as that used at the U.S. airports unloaded the van containers from the plane. As soon as the containers were unloaded, the lettuce boxes were removed and loaded into delivery trucks.

At the Rotterdam, The Netherlands, port when the surface ship arrived the van containers were discharged to await customs clearance. The Army terminal in Rotterdam provided the necessary papers--forms AE-302 (a universal customs document for all goods destined for the U.S. forces in Europe) and DD-1384 (a transportation control and movement document). Before arrival of the shipment advanced clearance was obtained for minimum delay in passing through the port.

The van containers were unloaded from the ship by a shoreside gantry crane, placed on a truck chassis, and moved to their final destination. When transported by truck, the van containers were stopped at the Dutch-German border for customs clearance. This was a routine matter handled at the border by a customs broker employed by the trucking company. The van containers then proceeded to the Kaiserslautern, West Germany, Cold Storage Facility. When transported by container train, the van containers were loaded Sunday night in Rotterdam and delivered in Kaiserslautern on Monday morning. These moved on a through-bill arranged by the carrier for surface transportation from the growing fields to final destination. This transport permitted movement of the van container across international boundaries with no customs inspection until final destination.

Some bruise damage and resulting deterioration were caused by the rough handling during loading and unloading. Figure 4 shows a West German dock worker throwing a box of lettuce during the unloading of an air shipment which caused bruising of the lettuce.

Data Collecting

ARS researchers collected data and made initial observations in the growing areas on harvesting, packaging, cooling, loading operations, and the handling equipment used. Time and cost studies determined the labor

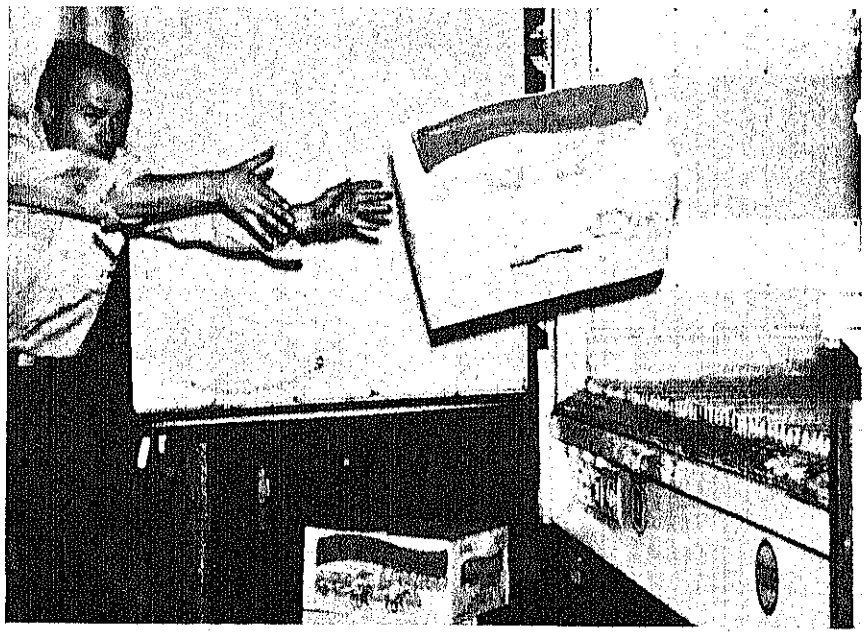

Figure 4.--A West German dock worker throwing a box of lettuce at time of unloading.

requirements. The same researchers accompanied the shipments to the ports of embarkation and observed the loading of the igloos or the LD-3s aboard the aircraft, or of the van containers aboard the containerships. Other researchers witnessed the unloading of these containers at the overseas ports or airports and recorded additional transport and handling data. Destination data, including information on unloading, handling, load patterns, physical damage, labor requirements, temperatures, and arrival condition of the product, were also collected.

The Army and the DSA personnel collected the spoilage data. The U.S. Army Subsistence Quality Assurance inspectors at the Kaiserslautern, West Germany, Cold Storage Facility measured the spoilage. This is a standard service practice. Lettuce was inspected on arrival and at 5-, 10-, and 15-day intervals after arrival. Spoilage data were also collected at commissaries in Frankfurt, Zweibrucken, Ramstein, and Vogelweh, West Germany. The Army Audit Agency substantiated all the data collected in the United States and Europe. Furthermore, all data collected were subject to review by an evaluation team consisting of Department of the Army representatives and U.S. Department of Agriculture researchers.

Spoilage data gathered by Army Subsistence units during the 1972 test period are cited in this study where there is a relationship between improvements recommended by USDA in handling, loading, and transporting procedures and a significant reduction in spoilage losses attributable to these improvements.5/

During the 1970 transport tests, the spoilage data collected by the Army Subsistence units in Germany required further verification by the military conducting the tests.

Transport charges from origin to destination were obtained from the Government bills-of-lading and carriers' tariffs. Records of the length of time required for loading and transporting each shipment were also kept.

The transit air temperatures of the lettuce in the test boxes were recorded by Ryan thermographs. The test lettuce boxes were placed in the top, middle, and bottom layers in the center stack 8 feet from the rear of the trailer.

PHYSICAL PERFORMANCE

The transit time required for moving lettuce boxes from origin to destination on surface and air shipments and the lack of care in loading and unloading were some of the more important reasons for spoilage. Because lettuce is one of the most perishable of commercially shipped vegetables, precooling to desirable transit temperatures of 32° F and careful handling are required to

5/ The spoilage data were collected over a 6-month period involving 26 weeks of matched air cargo and surface shipments of 3,300,000 pounds of lettuce shipped by surface and 1,600,000 pounds of lettuce shipped by air cargo.

prevent spoilage. If the shipments had been properly refrigerated, the transit time involved probably would not have affected the product to a serious extent.

Transit Time

Transit time is critical to the overseas transport of lettuce because product shelf life starts to diminish at the time of harvest and continues until the lettuce is consumed. The transit time from origin to destination for the surface (van container) shipments was most critical. Although the van container carriers made every effort to expedite these test shipments, the containerships used to cross the Atlantic were not the most modern. The transit time profiles (tables 1 and 2) indicate the long periods of time required for the Atlantic crossing.

Analysis of transit times indicates that movements to the ports and airports were very time consuming. For instance, ocean transportation averaged only 54 percent of the total transit time in surface shipments, while movements to and from the ports averaged 46 percent. In air shipments, 70 percent of the total transit time was used in movements to and from the airports.

In the 1970 surface shipments, the containerships were generally rebuilt World War II cargo ships converted for container service. Their speed was 12 to 14 knots. Although the average ocean crossing time for these ships was 9 to 10 days, one of the crossings exceeded this timespan because of mechanical difficulties en route (tables 1 and 2). Furthermore, at the overseas port some shipments were delayed a day or two for connections with the container train from Rotterdam to Kaiserslautern. One shipment was delayed at the port for over a week due to the lack of a phytosanitary certificate.

In the 1972 shipments, the containerships were newer and faster, but there was no significant improvement in overall transit time because of delays encountered at the ports or in delivery at destination.6/

A comparison of the 1970 and 1972 transit times indicates that the average surface transit time of 19.5 days for 1972 is somewhat improved over the 21.6 days for 1970. However, even in 1972, too many unnecessary delays were encountered, such as poor ship scheduling, mechanical difficulties, and lack of adequate documentation.

Transit time from both New York and California to the American ports was good. In the 1970 tests, the lettuce boxes source-loaded in the field in van containers were subjected to much less handling damage than the 1972 shipments,

6/ Since this project was completed, there have been significant improvements in the ocean transport with the introduction in 1973 by Sea-Land of the SL'7 class of ships which are capable of attaining 33 knots and crossing the Atlantic in 4 days. Other carriers also have introduced new containerships, with 25- and 28-knot speeds, which have reduced the ocean transit time. Currently (1976), the SL'7 ships are averaging 28 knots and 5-day-transit time from U.S. East Coast ports to Rotterdam.

Table 1.--Transit time profile for lettuce transported by air and surface from the United States to West Germany, 1970

Test shipment	Transport		Transport to port		Port of embarkation		Ocean crossing		Port of destination		Transport to destination		Total time in transit
	Origin	Destination	Number of days in transit	Percent of total transit time	Number of days in transit	Percent of total transit time	Number of days in transit	Percent of total transit time	Number of days in transit	Percent of total transit time	Number of days in transit	Percent of total transit time	Number of days
Surface	New York	West Germany	1	6	1/ 4	22	9	50	2	11	2	11	18
Air	do.	do.	1	33	--	--	1	33	--	--	1	33	3
Surface	do.	do.	1	6	1/ 3	16	12	66	1	6	1	6	18
Air	do.	do.	1	33	--	--	1	33	--	--	1	33	3
Surface	do.	do.	1	4	1/ 3	13	12	50	2/ 7	29	1	4	24
Air	do	do.	1	33	--	--	1	33	--	--	1	33	3
Surface	Calif.	do.	4	17	1/ 3	13	14	58	1	4	2	8	24
Air	do.	do.	1	33	--	--	1	33	--	--	1	33	3
Surface	do.	do.	6	24	1/ 3	12	12	48	1	4	3	12	25
Air	do.	do.	1	25	--	--	1	25	3/ 1	25	1	25	4
Surface	do.	do.	4	19	1/ 4	19	11	52	0	0	2	10	21
Air	do.	do.	1	25	--	--	1	25	4/ 1	25	1	25	4

1/ Delayed awaiting sailing of containership.
2/ Delay due to lack of phytosanitary certificate.
3/ Delay of 12 hours at airport before delivery.
4/ Delay of 16 hours at overseas airport before delivery.

Table 2.--Transit time profile for lettuce transported by air and surface from the United States to West Germany, 1972

Test shipment	Transport		Transport to port		Port of embarkation		Ocean crossing		Port of destination		Transport to destination		Total time in transit
	Origin	Destination	Number of days in transit	Percent of total transit time	Number of days in transit	Percent of total transit time	Number of days in transit	Percent of total transit time	Number of days in transit	Percent of total transit time	Number of days in transit	Percent of total transit time	Number of days
Surface	Calif.	West Germany	4	17	1/ 3	13	11	48	2/ 4	17	1	5	23
Air	do.	do.	1	25	--	--	1	25	3/ 1	25	1	25	4
Surface	do.	do.	4	17	1	5	9	41	4/ 7	32	1	5	22
Air	do.	do.	1	33	--	--	5/ 1	33	--	--	1	33	3
Surface	do.	do.	4	25	1	6	8	50	1	6	2	13	16
Air	do.	do.	1	33	--	--	1	33	--	--	6/ 1	33	3
Surface	do.	do.	4	26	1/ 2	7	8	53	1	7	1	7	16
Air	do.	do.	1	33	--	--	1	33	--	--	6/ 1	33	3
Surface	do.	do.	4	21	1/ 2	11	10	56	1	6	1	6	18
Air	do.	do.	1	33	--	--	1	33	--	--	7/ 1	33	3
Surface	do.	do.	4	18	2/ 2	9	8	36	8/ 7	32	1	5	22
Air	do.	do.	1	25	--	--	1	25	9/ 1	25	1	25	4

1/ Delay due to late arrival of containership.
2/ Delayed 2 days due to mechanical failure of engine in refrigeration unit.
3/ Shipment arrived at airport at midnight; unloaded following morning.
4/ Delayed 6 days awaiting the phytosanitary certificate.
5/ Delay of 9½ hours before delivery.
6/ Delay of 6½ hours before delivery.
7/ Delay of 11½ hours at airport before delivery.
8/ Delay due to lack of generator for rail shipment to Kaiserslautern.
9/ Delay of 15½ hours before delivery.

which had to be transloaded at the port. The transloading subjected the boxes to at least three additional handlings, which took its toll in damaged lettuce boxes and bruised lettuce.

Despite the overland distance involved in the California shipments, none of the shipments was delayed en route to the port. From Salinas, surface carriers held to a very tight schedule and provided delivery on the fourth morning. All of the test shipments, once they reached the port, were delayed 2 or 3 days waiting for the containership. The greatest delays occurred with the containerships which were beset with many mechanical and scheduling problems. For example, although the containership sailings were usually set for Saturday, actual sailings generally took place on Mondays.

Transit air time was not crucial. Most shipments were brought to the San Francisco airport on a Monday evening and were in Frankfurt, Germany, by Tuesday afternoon. Transit air time became important only when poor scheduling was involved and a shipment missed a particular flight. When this happened, the shipment often remained from 8 to 24 hours on the dock exposed to ambient temperatures awaiting the next flight. Likewise, at the overseas airport the regularly scheduled all-cargo flights occasionally did not maintain their schedules. Hence the arrival of the flights after working hours necessitated the shipment being held on the receiving dock until the following day (see footnote references to tables 1 and 2).

In the overseas area, because the delivery trucks were not refrigerated, all air shipments of lettuce were exposed to ambient temperatures from the time the plane arrived at the overseas airport until the lettuce was finally delivered to the consignee. This timespan varied from 2 to 24 hours, which caused the lettuce to deteriorate.

Temperatures

The transit temperatures of the air shipments varied on the circumstances and the delays in transit. With vacuum cooling at the shipping point and delivery to the airport in a refrigerated truck, the temperature of the lettuce did not reflect these conditions, as shown in figures 5, 6, and 7.

The nonrefrigerated igloo shipments showed that lettuce temperatures were generally at acceptable levels when they were loaded aboard the planes; however, a gradual heating-up process commenced so that the temperatures upon overseas arrival were around 50° F (figs. 5 and 6).

The shipment of different products with different temperature requirements stored in the same refrigerated compartment of the plane posed a problem. For instance, in two of the air shipments live animals with 60° F temperature requirements were in the same cargo compartment as the lettuce with 32° requirements. In two other air shipments delays of 24 and 18 hours subjected the lettuce to high ambient temperatures (figs. 5 and 6).

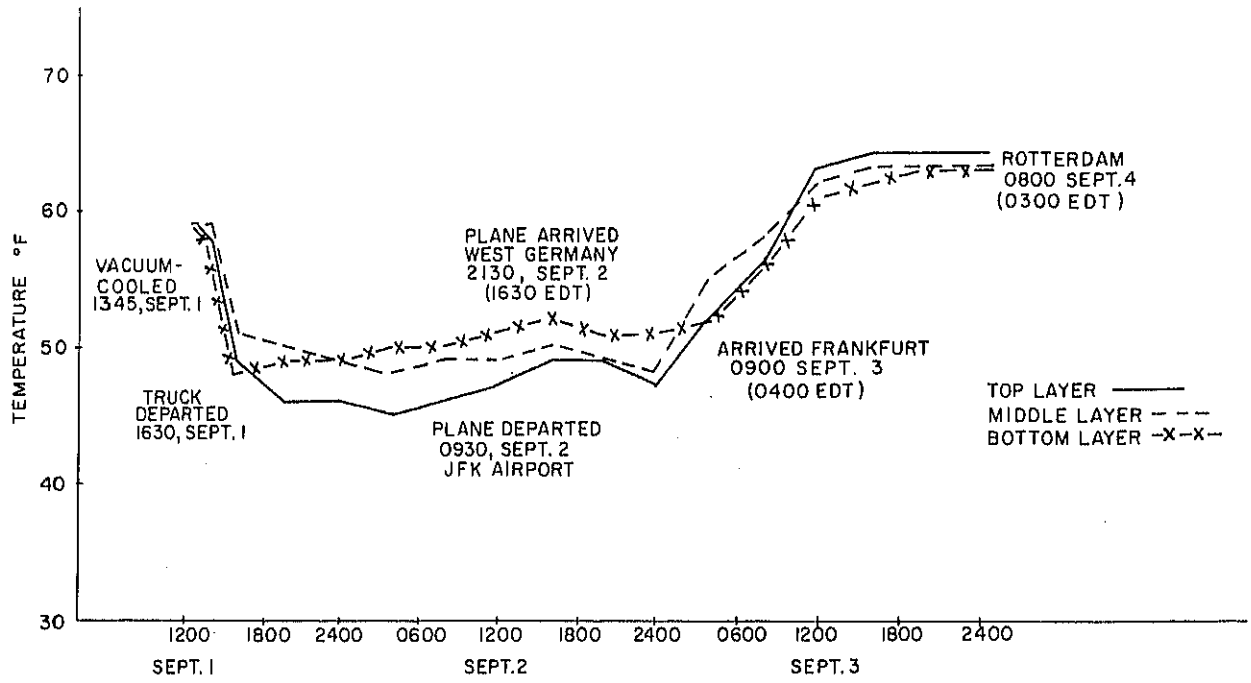

Figure 5.--Transit temperatures taken September 1 to 3, 1970, in lettuce boxes airshipped from New York, N.Y.

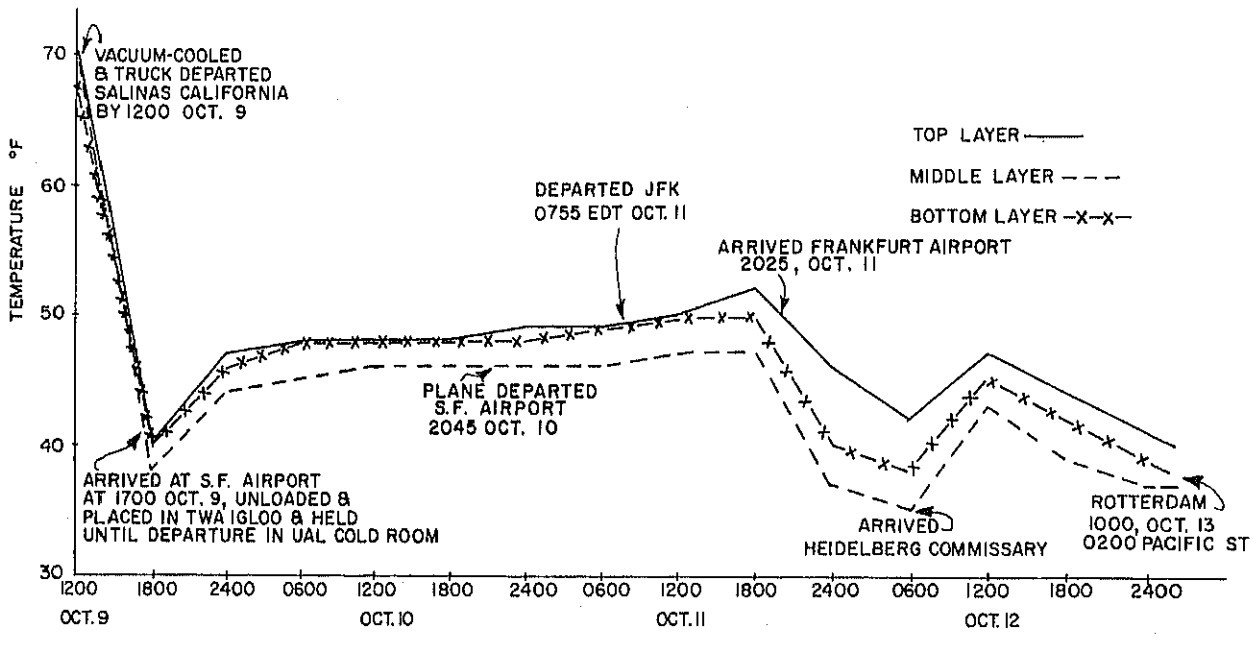

Figure 6.--Transit temperatures taken October 9 to 12, 1970, in lettuce boxes airshipped in nonrefrigerated Type A-2 igloos from Salinas, Calif.

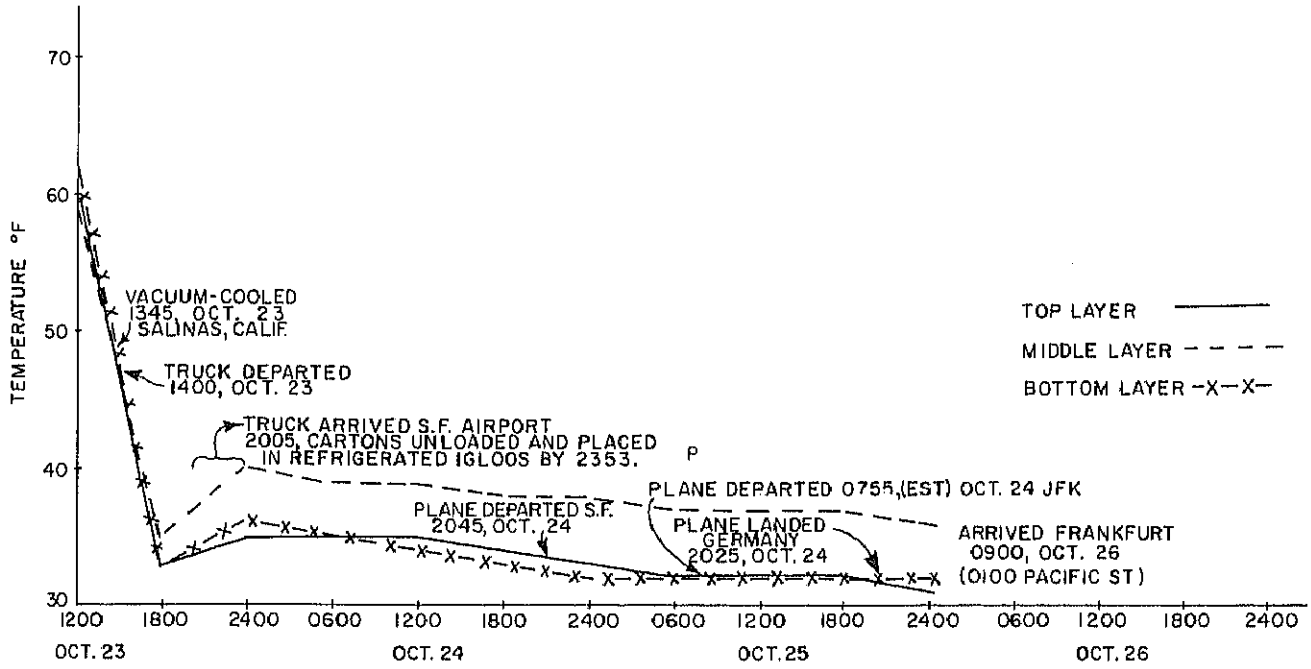

Figure 7.--Transit temperatures taken October 23 to 26, 1970, in lettuce boxes airshipped in a refrigerated igloo from Salinas, Calif.

In one experimental shipment, boxes of lettuce were placed in an experimental refrigerated igloo.7/ Upon arrival at the airport, the lettuce was placed immediately in a refrigerated igloo. Although airplane departure was 19 hours late, the lettuce remained under refrigeration during the delay. In contrast to the temperatures shown in figures 5 and 6, the temperatures of this shipment remained more uniform and closer to the desired levels, although there was no forced air circulation in the igloo. Some lettuce in the top row next to the coils sustained some freeze damage.

Figures 8 and 9 show temperatures of lettuce in boxes in van containers from the time of packaging at harvest to the time of arrival at overseas commissaries. At time of packaging, the temperature of the lettuce in boxes was 58° F. After 6 days in transit (fig. 9), because of inadequate circulation in the van container, the temperature in the middle layer was only 45°; that in the bottom layer, 45°; and that in the top layer, 36° F.

Vacuum cooling was inadequate because temperatures of the lettuce were lowered from 58° to only 48° F instead of to 38°, at which vacuum cooler thermostats were set (fig. 9).

Significantly (fig. 8), lettuce heated up from 40° to 50° F, beginning from the 18th day when the container was unloaded from the ship until the lettuce was delivered to the cold storage warehouse. In contrast (fig. 9), much

7/ This was the only experimental shipment in which a refrigerated igloo was used. The igloo was loaned to the shipper on a one-time, experimental basis.

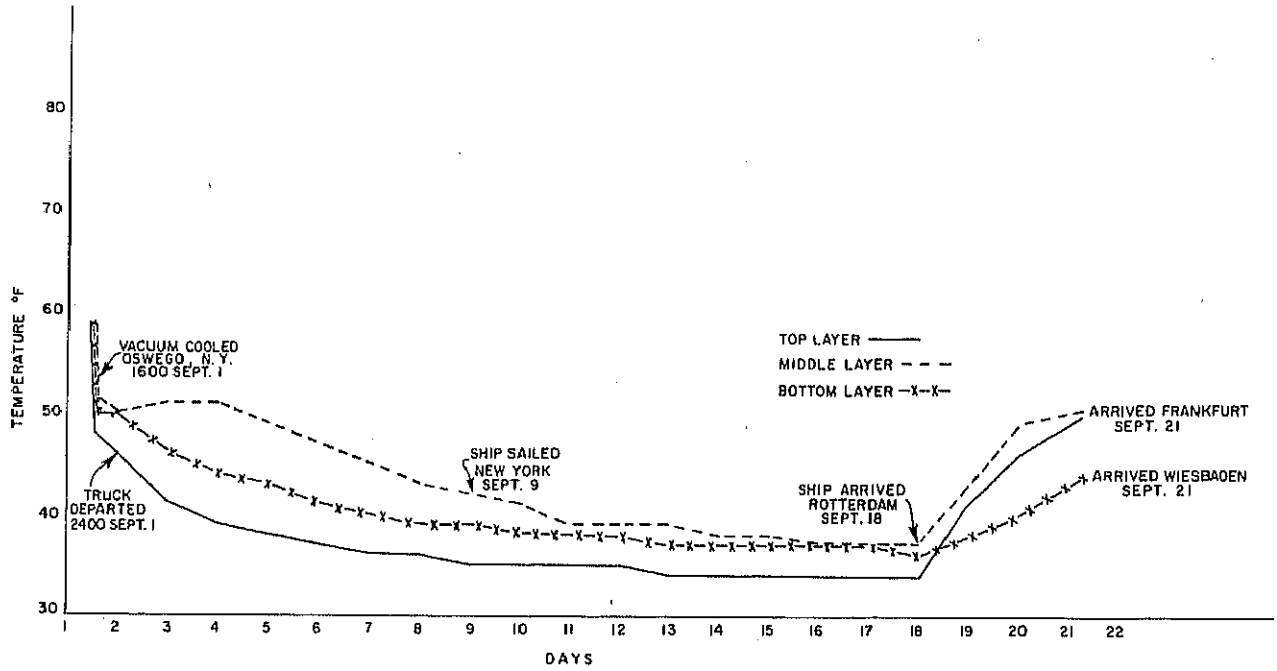

Figure 8.--Transit temperatures taken September 2 to 22, 1970, in lettuce boxes surface shipped (van container) from Oswego, N.Y.

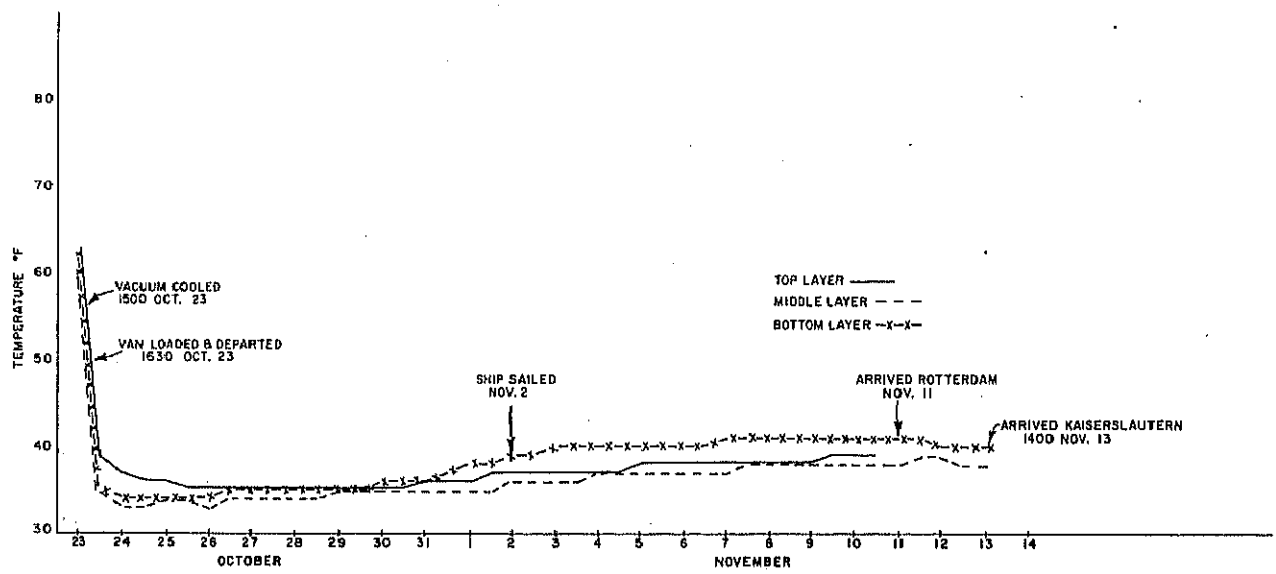

Figure 9.--Transit temperatures taken October 23 to November 13, 1970, in lettuce boxes surface shipped in refrigerated van container from Salinas, Calif.

improved temperatures in the lettuce boxes occurred from the time of harvest, at 62°, after vacuum cooling to 50° and to 38° and, finally, to 36° F after 1 day in transit.

Load Patterns

The load patterns used in the 1970 and 1972 tests were different. In 1970 the van containers were source-loaded and the ocean carrier suggested a 5 by 4 conventional lengthwise air-flow or horizontal channel pattern. The boxes were loaded directly on top of one another with air channels installed in a straight line from front to rear and the top closed (fig. 10). The air circulation openings were lengthwise from the front to the rear stack. With a header stack installed next to the bunker or bulkhead and the top layer of boxes loaded tightly together, the circulation of the air was from the front over the top of the load to the rear and through the load.

In the 1972 test shipment a bonded-block pattern (figs. 11 and 12) was used. The singular feature of this pattern was that the boxes were bonded, every two rows the boxes went from lengthwise to crosswise. The air channels were over and under the boxes and the top layer had openings between the boxes.

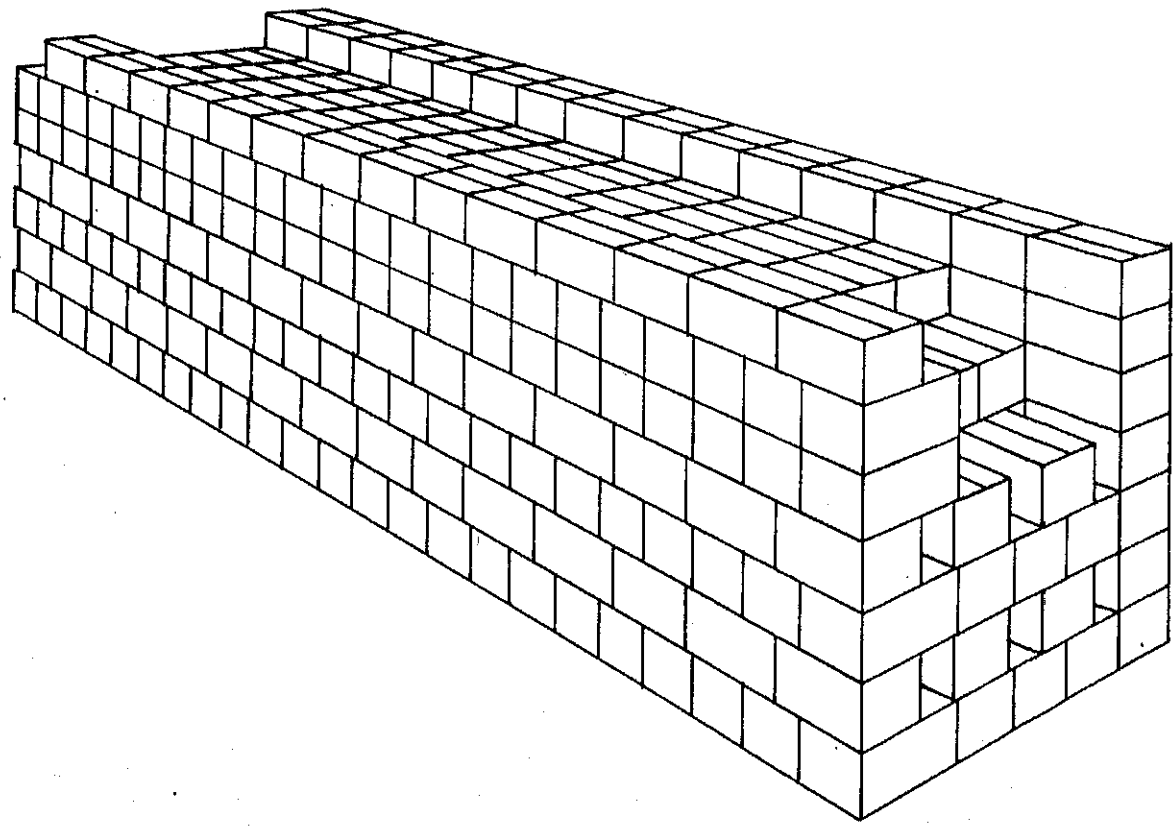

Figure 10.--Conventional (5 x 4) lengthwise air-flow pattern.

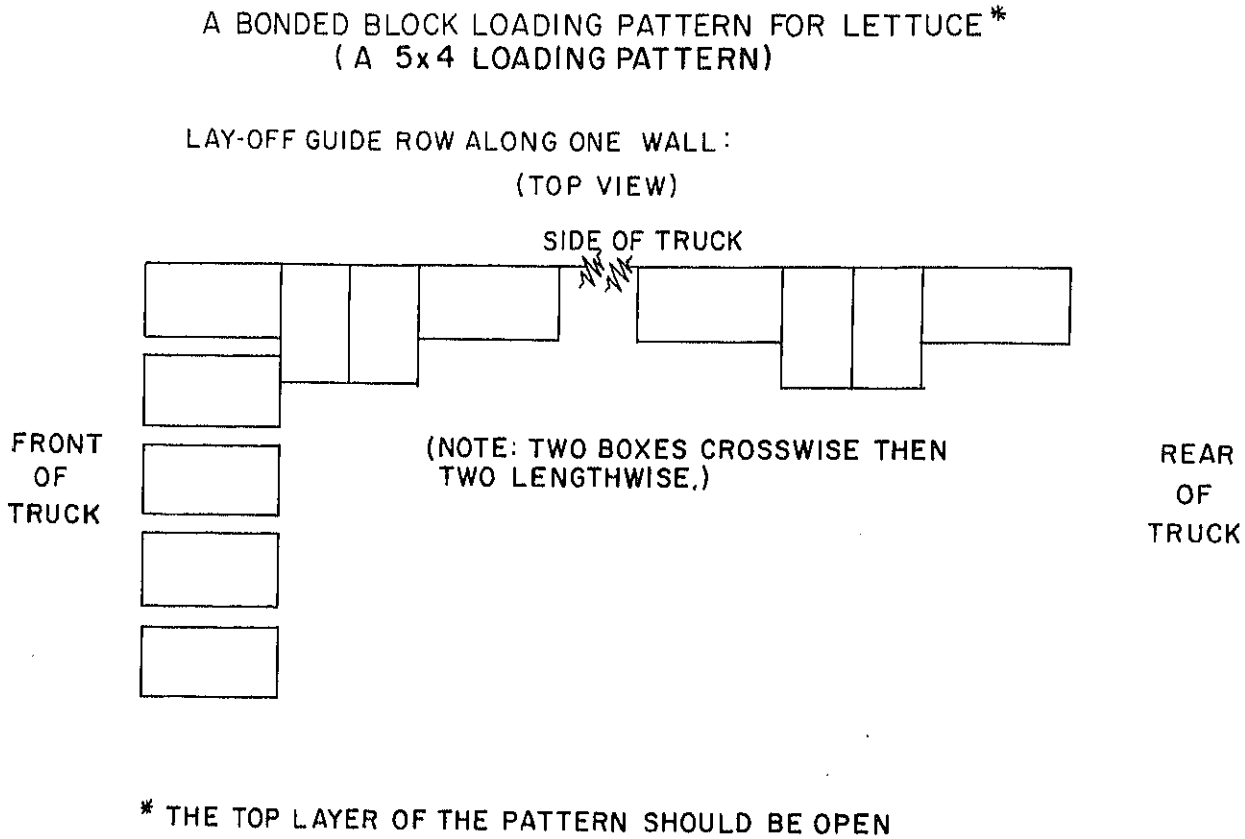

Figure 11.--Method of laying off the bonded-block loading pattern. (Note: Two boxes crosswise, then two lengthwise.)

In the 1970 surface shipments, 500 wax-impregnated boxes of lettuce were source-loaded into a 35-foot refrigerated van container and trucked to the New York port.8/ The 5 by 4 conventional lengthwise pattern made for a tight load with air channels only in the four lengthwise stacks (fig. 10).

In the 1972 surface shipments, 800 boxes of lettuce were tight-stacked in a 40-foot refrigerated trailer truck and transported to Cheathem Annex, Va., where they were transloaded into van containers. With five boxes lengthwise and three crosswise in a bonded-block pattern, 658 boxes were loaded into a 40-foot van container. This 5 by 3 pattern was simplified and made somewhat more compact because a header stack was not used at the front of the load.

Reduced spoilage losses of lettuce in transit appeared to be directly connected with the use of the bonded-block pattern adapted to the corrugated fiberboard box. This pattern allowed the circulating cooled air in the

8/ With variations in the inside dimensions of van containers, the number of boxes which a particular load pattern will take varies with the dimensions of the fiberboard box as well as those of the container.

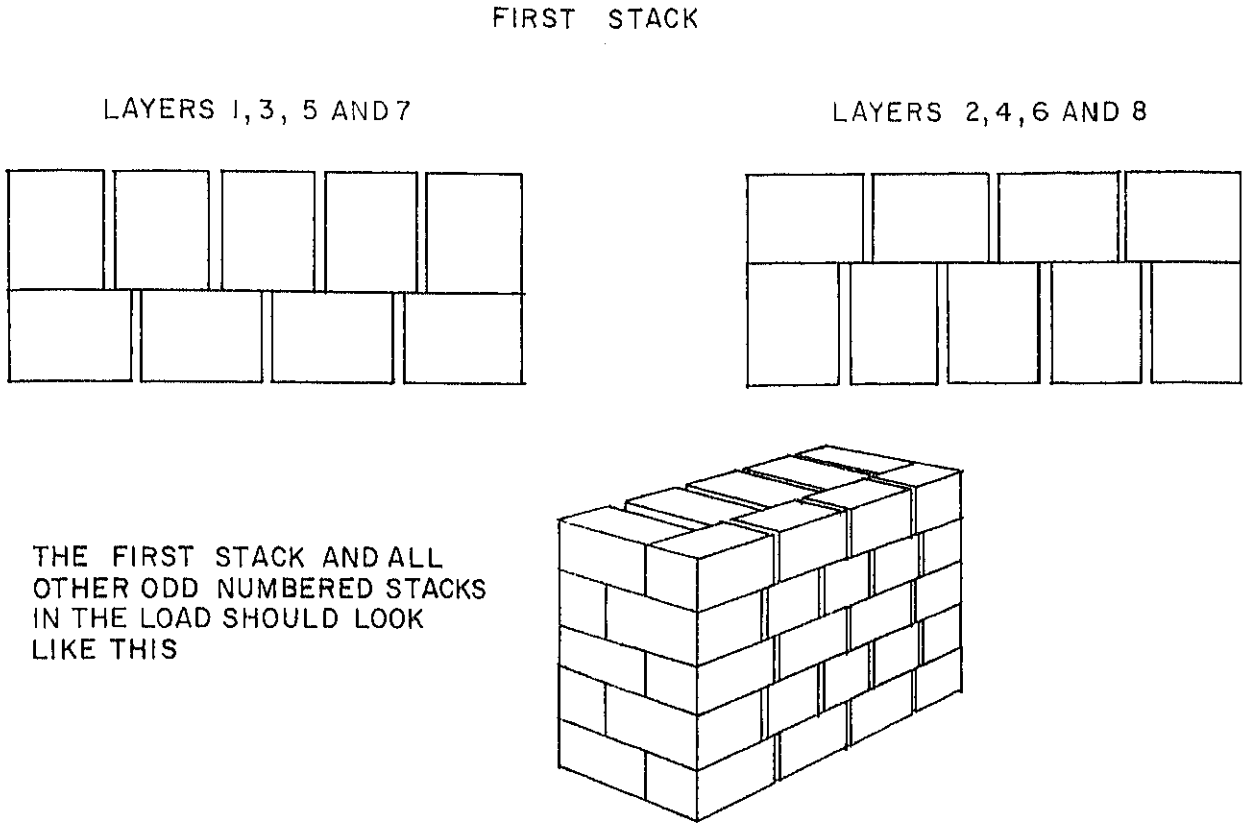

Figure 12.--Layer arrangement and basic stack for the bonded-block pattern.

refrigerated van container to penetrate the interior of the load mass for effective cooling of the lettuce. The bonded-block pattern with no header stack more than satisfied the requirements of an acceptable loading pattern. This bonded-block pattern:

- Was practical and not too complicated for the loaders to use
- Lent itself to rapid loading
- Was readily adaptable to any size of transport vehicle
- Was compact enough to provide a payload for the transport vehicle
- Had adequate channels for air circulation throughout the load
- Was sufficiently stable to remain intact during transit
- Helped prevent container failure and product damage

To compare the cooling rates of these two load patterns, a series of static tests was made. These tests consisted of monitoring temperatures at periodic intervals in two van containers loaded with lettuce--one with a bonded-block pattern and the other in the conventional lengthwise pattern. Twenty-four thermocouple leads were imbedded in lettuce through each of the loads to permit a representative sample of temperature readings. Temperature readings were taken over a 60-hour period by a portable potentiometer. Upon completion of the test, stick thermometer temperatures of the lettuce were taken.

Figure 13 shows the temperature results of the static tests. These results suggest that there was more air circulation in the bonded-block load pattern than in the conventional lengthwise load since the lettuce in the bonded-block load cooled faster. After a 24-hour period, this became more apparent when the temperatures in the bonded-block load began to fall while those in the lengthwise load began to rise. Figure 14 shows the same results on pulp temperatures at completion of static tests (unloading). The average temperature for the bonded-block load was 33.1° F and the average for the conventional lengthwise load was 38.6°.

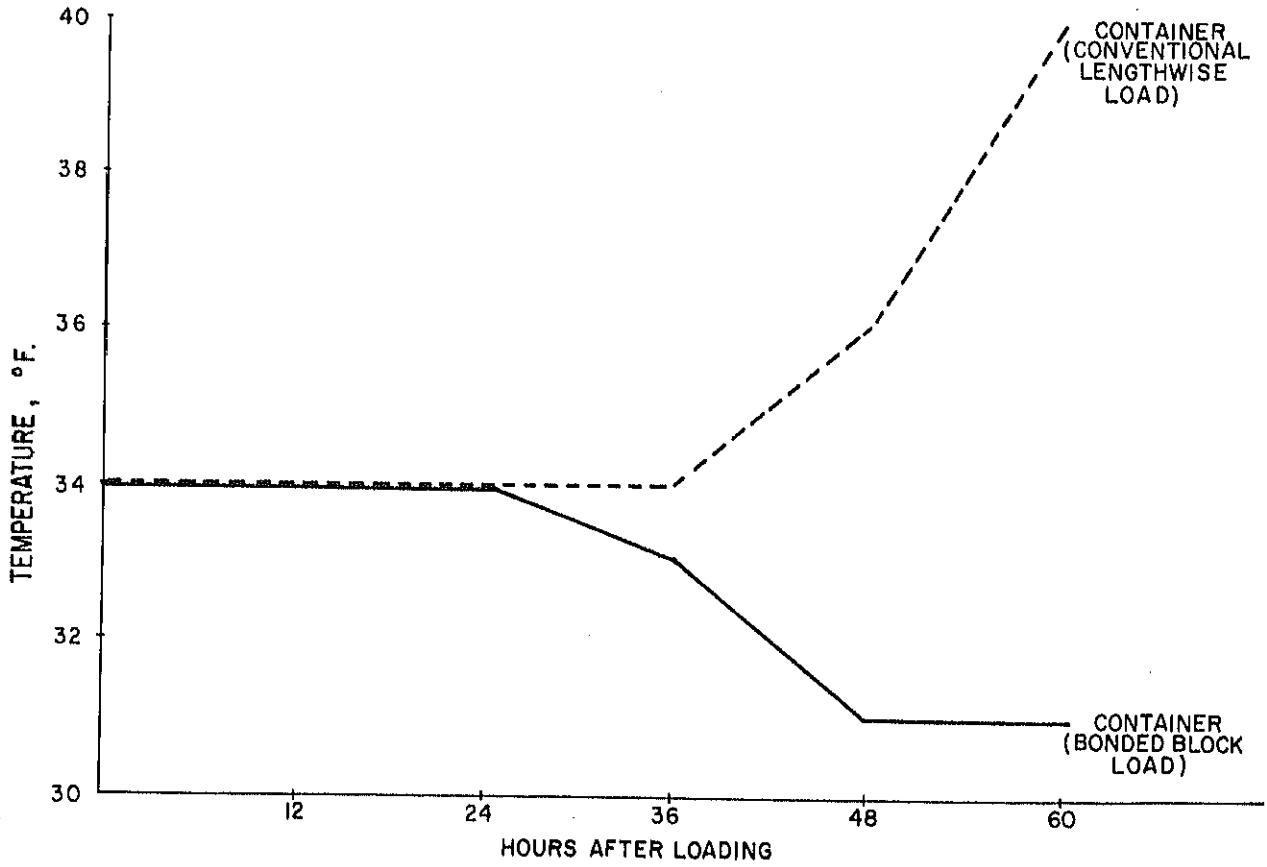

Figure 13.--Pulp temperatures taken by thermocouples imbedded in lettuce in various locations in loads by load patterns installed (static tests), December 9 to 10, 1972.

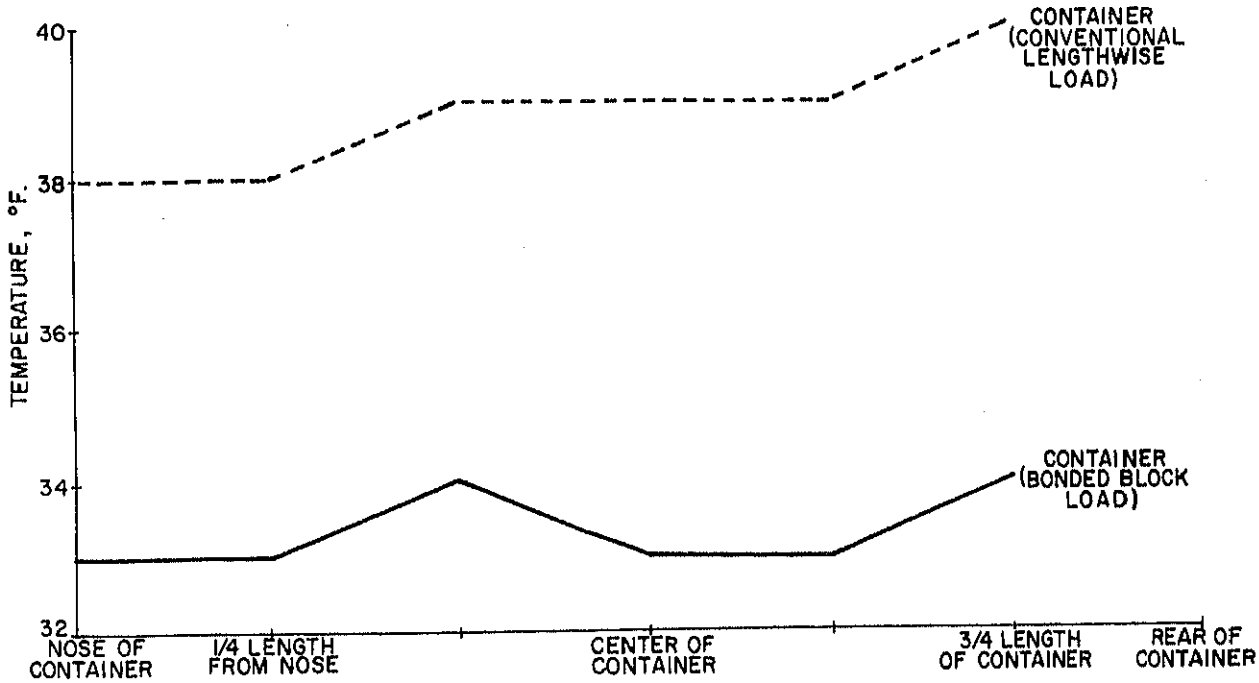

Figure 14.--Lettuce pulp temperatures taken by load pattern at completion of static tests (unloading), December 9 to 10, 1972.

In addition to the temperatures, the bonded-block pattern compared favorably on load count. With the exception of the 20-foot van container, the bonded-block pattern required more lettuce cartons than the lengthwise pattern (table 3).

Table 3.--Number of boxes in bonded-block and conventional lengthwise load patterns 1/

Van container size (outside length, foot)	Number of boxes in--	
	Bonded-block (5x4) load	Conventional lengthwise (5x4) load
40	715	628
35	589	526
28	413	380
20	266	278

1/ Comparison of numbers of lettuce boxes with the two different types of load patterns was made in connection with the static tests. The discrepancy between the number of boxes listed and the number previously reported can be attributed to varying interior dimensions of containers and fiberboard boxes used.

Spoilage data collected by the Department of the Army over a 6-month period (table 4) substantiated the spoilage data referred to in this report. The static tests indicated that the air and pulp temperatures of the lettuce loaded in the USDA-recommended load pattern (bonded-block) averaged 5° F less than those of the conventional lengthwise load pattern. Spoilage data collected during the 1972 tests on shipments which were loaded with USDA-recommended load patterns showed spoilage losses of only 5.7 percent on arrival and 6.7, 9.2, and 11.8 percent, respectively, 5, 10, and 15 days after arrival (table 4).

Compared with the average 20- to 25-percent normal spoilage losses incurred by military commissaries up to this time, these new spoilage losses of 5.7 and 6.7 percent were significant.9/ The reduced spoilage losses were attributable to two changes: (1) The substitution of the bonded-block load pattern for the conventional lengthwise air-flow or horizontal channel patterns, and (2) the reduction in the handling of the shipments.

A standard for judging the practicality of a load pattern is the ease with which loaders learn and accept it. At a cold storage warehouse and in growing areas, loading crews had no difficulty in memorizing the bonded-block pattern. The loaders took about the same amount of time to load by the bonded-block pattern as they did to load by the conventional lengthwise pattern.

In air shipments load patterns were not of any great importance because of their short transit time. There was no specific load pattern used in the loading of the Type A-2 igloo or the LD-3 container. All air shipments were loaded into these containers at random. Very often, because of the limited loading space in the LD-3 container and its peculiar configuration, some of the lettuce boxes were jammed into space too small to accommodate them. This caused box and lettuce damage.

TRANSPORT CHARGES

The conditions for transport agreed to by the ocean carrier and the Government in 1972 were the same as those in 1970. The Government was responsible for loading at origin and unloading at destination. The rate was based on either a weight or measurement basis. The latter basis produced the higher freight charge, due to the light and bulky nature of lettuce. The lettuce shipments were rated on a measurement ton (MT) basis according to the cubical capacity of the van container.

Table 5 compares the transport charges in 1970 for moving iceberg lettuce by air and surface (van container) from the United States (New York and California) to West Germany. The total average transport charges for the air test shipments were 24.9 cents per pound from New York and 32.8 cents per pound from California. For surface test shipments, charges were 9.7 cents per pound

9/ Figures of 20 to 25 percent spoilage were stated to the author by representatives of the Office of Subsistence Policy and Management of the Assistant Secretary of Defense for Installation and Logistics during the inception of these tests.

Table 4.--Cost and spoilage rates for lettuce shipped by van container from the United States to West Germany over a 6-month period in 1972 1/

Cost elements	Total dollars	Cost 2/ per lb., dollars	Percent of cost	Percentage of spoilage rate on arrival at--					
				Cheathem, Va. 3/	Rotterdam 3/	Kaiserslautern 4/	Kaiserslautern 4/ after storage days of-- 5	10	15
Product	396,143	0.106	38	4.4	1.8	5.7	6.7	9.2	11.8
Carton cost	39,616	.010	4	4.4	1.8	5.7	6.7	9.2	11.8
Cooling cost	4,952	.001	1	4.4	1.8	5.7	6.7	9.2	11.8
Drayage to Cheathem, Annex, Va.	210,390	.056	20	4.4	1.8	5.7	6.7	9.2	11.8
Port charges	53,128	.014	5	---	1.8	5.7	6.7	9.2	11.8
Port to Kaiserslautern, West Germany	274,384	.073	26	---	1.8	5.7	6.7	9.2	11.8
Handling and transportation at Kaiserslautern and at commissaries	64,769	.017	6	---	---	5.7	6.7	9.2	11.8
	1,043,382	.277	100	---	---	---	---	---	---

1/ Table developed from data obtained by the Department of the Army in the process of monitoring and supervising the lettuce test.

2/ The price of product is based on the average cost of lettuce for the entire test. A total of 99,040 cartons totaling 3,737,196 pounds were shipped by surface from California.

3/ This represents lettuce that was rejected by the carriers and not transported any further in the supply system.

4/ These spoilage rates are based on lettuce that arrived at the Cold Storage Facility in Kaiserslautern, Germany.

Table 5.--Transport charges for moving iceberg lettuce by air and surface (van container) from the United States to West Germany, 1970

Test shipment 1/	Origin	Destination	Weight pounds	Inland charges to U.S. ports or airports 2/		Ocean charges 3/		Overseas inland 4/ charges to destination		Total transport charges 5/	
				Total dollars	Cents per pound	Total dollars	Cents per pound	Total dollars	Cents per pound	Total dollars	Cents per pound
Air	New York	West Germany	10,500	188.30	1.8	2,152.00	20.5	358.78	3.4	2,699.08	25.7
Surface	do.	do.	22,500	261.69	1.8	1,641.78	7.3	137.28	0.6	2,040.75	9.7
Air	do.	do.	10,500	183.75	1.8	1,992.00	18.9	365.78	3.5	2,541.53	24.2
Surface	do.	do.	22,500	261.69	1.8	1,641.78	7.3	137.28	0.6	2,040.75	9.7
Air	do.	do.	10,500	183.75	1.8	2,082.00	19.8	358.78	3.4	2,624.53	25.0
Surface	do.	do.	22,500	261.69	1.8	1,641.78	7.3	137.28	0.6	2,040.75	9.7
Air	California	do.	5,250	26.77	0.50	1,328.25	25.3	358.78	6.8	1,713.80	32.6
Surface	do.	do.	22,500	1,450.10	5.6	1,632.22	6.3	136.48	0.6	3,218.80	12.5
Air	do.	do.	5,250	27.83	0.5	1,442.10	27.5	288.12	5.5	1,758.05	33.5
Surface	do.	do.	22,500	1,450.10	6.4	1,637.00	7.3	136.90	0.6	3,224.00	14.3
Air	do.	do.	5,250	30.98	0.6	1,442.10	27.5	218.36	4.2	1,691.44	32.2
Surface	do.	do.	22,500	1,450.10	6.4	1,632.22	7.3	136.48	0.6	3,218.80	14.3

1/ Van container shipments used in 35-foot units.
2/ Charges based on a per unit or van container.
3/ Ocean charges based on a weight or measurement basis.
4/ Inland charges computed on a unit or van container.
5/ Average transport charges from New York for air shipment were 24.9 cents per pound and for surface shipment 9.7 cents per pound; those from California were 32.8 and 13.7, respectively. The differentials were 15.2 cents per pound for New York and 19.1 for California.

from New York and 13.7 cents per pound from California. The surface charges for hauling the van container from California to New Jersey amounted to $1,450.10.

Table 6 shows that ocean charges amounted to 6 cents a pound in 1972, in comparison with 7 cents a pound in 1970. This difference resulted from use of 35-foot unit van containers in 1970 while in 1972, 40-foot units were used.

The principal reason that the transport charges for surface shipments were less in 1972 than in 1970 was the lower surface charges. Although there was not much difference in the surface transport charges to U.S. ports or airports for 1972, there was a significant difference in the overseas surface charges. For instance, table 5 shows that in 1970 the overseas surface transport charges for the air shipments varied from 3.4 cents per pound to 6.8 cents per pound. In the 1972 test shipments, the overseas surface transport charges amounted to only 5 cents per pound.

Table 7 presents 1976 transport charges by both air and surface for moving iceberg lettuce of similar quantities as those moved in 1972 shipments. The ocean rate for 1976 was $64.90 per MT for 48.85 MT (cubic capacity of a 40-foot container) or $3,170.37 for a surface (van container) load. This represents a 195-percent increase in charges from 1972 because of inflation and the energy crisis. The effects of inflation and the energy crisis on transport charges are reflected in the data. At the current (1976) cost of lettuce, $4.00 a box, air-transporting lettuce to West Germany costs more than producing the lettuce.

Surface and air transport charges constituted the major portion of the total transport costs. In averages of all the 1970 tests, 80 percent of the air transport costs were for the air carriers and 63 percent of the surface transport costs for the ocean carriers. In the 1972 tests, 94 percent of air transport charges were for the air carriers and 43 percent of surface transport charges were for the ocean carriers.

On the basis of 1976 figures, 58 percent of the total surface costs went to the surface carriers and 95 percent of the total air costs went to the air carriers. In 1972 there was a marked reduction in the surface overseas transport charges for the air shipments. The difference in the percentage of the containerized shipments was due to differences in the transports in 1970 and 1972. In 1970 the harvested lettuce from California was source-loaded in a container, whereas in 1972 the harvested lettuce from California was brought by refrigerated trailer truck to Norfolk where it was loaded into a van container.

U.S. Surface

The U.S. surface transport charges for 1970 air test shipments represent the freight charges for moving the shipment from the growing fields in Oswego, N.Y., and Salinas, Calif., to the closest airports, in New York and San Francisco. The truckers' charges for the surface shipments involved the movement of the van containers from both the New York and California growing areas to Port Elizabeth, N.J.

Table 6.--Transport charges for moving iceberg lettuce by surface and air (van container) from the United States to West Germany, 1972

Test shipment	Origin	Destination	Weight pounds	Inland charges to U.S. ports or airports		Drayage charges at port 2/		Ocean charges 3/		Overseas inland 4/ charges to destination		Total transport charges 5/	
				Dollars	Cents per pound	Dollars	Cents per pound	Dollars	Cents per pounds	Dollars	Cents per pound	Dollars	Cents per pound
Surface 1/	California	West Germany	26,000	1,924.50	7	97.70	0.4	1,521.19	6	164.62	0.6	3,708.01	14
Air	do.	do.	10,000	100.00	1	--	--	2,200.00	22	50.00	.5	2,350.00	23.5
Surface	do.	do.	26,000	1,681.50	6	97.70	.4	1,521.19	6	164.62	.6	3,465.01	13
Air	do.	do.	15,000	150.00	1	--	--	3,300.00	22	75.00	.5	3,525.00	23.5
Surface	do.	do.	26,000	1,717.50	6	97.70	.4	1,521.19	6	164.62	.6	3,501.01	13
Air	do.	do.	10,000	100.00	1	--	--	2,200.00	22	50.00	.5	2,350.00	23.5
Surface	do.	do.	26,000	1,781.40	7	97.70	.4	1,521.19	6	164.62	.6	3,564.91	14
Air	do.	do.	5,000	50.00	1	--	--	1,100.00	22	25.00	.5	1,175.00	23.5
Surface	do.	do.	26,000	1,650.00	6	97.70	.4	1,521.19	6	164.62	.6	3,433.51	13
Air	do.	do.	10,000	100.00	1	--	--	2,200.00	22	50.00	.5	2,350.00	23.5
Surface	do.	do.	26,000	1,686.00	6	97.70	.4	1,521.19	6	164.62	.6	3,469.51	13
Air	do.	do.	10,000	100.00	1	--	--	2,200.00	22	50.00	.5	2,350.00	23.5

1/ All van container shipments moved in 40-foot units.
2/ Drayage charges based on unit or van container.
3/ Ocean charges computed on weight or measurement basis.
4/ Inland charges based on unit or van container.
5/ Average transport charges from California by air were 23.5 and by surface 13.3 cents per pound with a differential of 10.2 cents per pound.

Table 7.—Transport charges for moving iceberg lettuce by surface and air (van container) from the United States to West Germany, 1976

Test shipment	Origin	Destination	Weight pounds	Inland charges to U.S. ports or airports		Drayage charge (transport)		Ocean shipments charges		Overseas inland charges to destination		Total transport charges 2/	
				Total dollars	Cents per pound	Total dollars	Cents per pound	Total dollars	Cents per pound	Total dollars	Cents per pound	Total dollars	Cents per pound
Surface	California	West Germany	26,000	2,100	8	13.78	5	3,170.37	12	153.01	5	5,437.16	21
Air	do.	do.	10,000	265	3	74.00	7	7,400.00	1/ 74	50.00	5	7,789.00	78
Surface	do.	do.	26,000	2,100	8	13.78	5	3,170.37	12	153.01	5	5,437.16	21
Air	do.	do.	10,000	265	3	74.00	7	7,400.00	74	50.00	5	7,789.00	78
Surface	do.	do.	26,000	2,100	8	13.78	5	3,170.37	12	153.01	5	5,437.16	21
Air	do.	do.	10,000	265	3	74.00	7	7,400.00	74	50.00	5	7,789.00	78
Surface	do.	do.	26,000	2,100	8	13.78	5	3,170.37	12	153.01	5	5,437.16	21
Air	do.	do.	5,000	133	3	74.00	7	7,400.00	74	50.00	5	7,789.00	78
Surface	do.	do.	26,000	2,100	8	13.78	5	3,170.37	12	153.01	5	5,437.16	21
Air	do.	do.	10,000	265	3	74.00	7	7,400.00	74	50.00	5	7,789.00	78
Surface	do.	do.	26,000	2,100	8	13.78	5	3,170.37	12	153.01	5	5,437.16	21
Air	do.	do.	10,000	265	3	74.00	7	7,400.00	74	50.00	5	7,789.00	78

1/ No through rate available, charges of 34 cents per pound from San Francisco to New York and 40 cents per pound from New York to Frankfurt, Germany. A commodity rate of $695 per igloo (5,000 lb) exists if the igloo is stuffed by the shippers. Because of conditions, the lettuce was shipped in boxes from Salinas area to San Francisco by truck and the carriers loaded the igloos.

2/ Average transport charges from California by air were 77.57 cents per pound and by surface 20.12 cents with a differential of 57.45 cents.

The air shipments in 1970 moved to the airport from Oswego, N.Y., to Kennedy International Airport by truck at a rate of $1.75 per hundredweight at a 26,000-pound minimum load. Although the air shipment weighed 10,500 pounds (150 boxes), the truck was always fully loaded with other DSA shipments.

The U.S. surface charge for moving the 1970 air shipments of lettuce from the Salinas area to the San Francisco airport was 51 cents per 100 pounds. The air shipments weighed only 5,250 pounds, with the balance a stopoff shipment for the cold storage warehouse in Alameda, Calif.

In 1972, the U.S. surface charge for moving the air shipment of lettuce from the Salinas area to the San Francisco airport was $1.00 per 100 pounds.

For a similar move in 1976, the U.S. surface charge amounted to $2.65 per 100 pounds, which represented a substantial increase from the 1970 and 1972 surface charges. The U.S. surface transport from the Salinas growing area for the van container shipments presented a logistics problem in 1970. Because this movement was not in the carrier's normal flow of traffic, special arrangements had to be made to provide empty refrigerated van containers in the growing areas on a weekly basis and to find a carrier to haul this van container across the country to Port Elizabeth, N.J. In addition, a two-man driving team was needed for this cross-country trip.

The U.S. surface charges for the 1972 test surface shipments involved moving the lettuce from the growing fields in Salinas, Calif., to the Norfolk, Va., area by refrigerated trailer truck, transferring the shipment into a van container, and a drayage charge for moving the van container to the port. Although at times the surface charge was greater than the ocean charge, the 3-day delivery schedule to the East Coast compensated for the increased cost. The lettuce was harvested and loaded Monday in Salinas and loaded into the van container in Norfolk on Friday morning.

For all of the U.S. surface charges mentioned above, the Government was responsible for loading at origin and unloading at destination. In addition, there was a demurrage of $12 per trailer for each additional 24 hours the trailer was detained beyond the free time for unloading as specified in the carrier's tender.

Ocean

Because the surface shipments moved on through-bills-of-lading, arrangements for this movement were made by the two carriers who submitted the tender.10/

These carriers made provisions for the surface transportation from the growing fields to the ports and also for the transportation from the overseas ports to the final destination. The tenders did not provide for a single rate from origin to destination. A combination of charges applied on these movements. The surface carriers' charges were added to or combined with the ocean

10/ Sea-Land Service, Inc., Freight Tariff No. 138, Item 190, September 14, 1970, and Trans World Airlines Cargo Tariff No. 3, Item 1002 CAB 206, 1970.

charges. The primary benefit of the through-bill to the shipper was that all necessary arrangements for the surface transport were provided for by the tendering carriers.

The ocean charges for the 1970 surface test shipments were $38.27 per MT based on 42.65 MT per 35-foot unit van container, and those for the 1972 surface test shipments were $31.14 per MT based on 48.85 MT per 40-foot unit van container.

Both the 1970 and 1972 carriers in their tariffs reserved the right to reject for transportation any lettuce shipment which in their judgment was not acceptable for shipment or where the pulp temperature of the lettuce was not within plus or minus 5 degrees of the specified transit temperatures. At the request of the Government, a temperature recorder was placed in each van container at a charge of $25.

The ocean carriers, at the request of the Government, submitted their tenders based on a minimum of 100 percent usage of the inside capacity of the van container. This rate basis encouraged loading to capacity to maximize utilization of available cube that would give the carrier more revenue per shipment. The rate tenders for the surface movements provided three separate rates: (1) For the U.S. surface move, (2) for the ocean factor, and (3) for the overseas movement from the port to final destination.

Table 8 presents the surface transport charges in 1970 for moving lettuce in the van container from origin to destination. Three rate factors involved in the move were : (1) The U.S. surface, (2) the ocean, and (3) the overseas surface. However, only two rates were listed on the Government bills-of-lading--the ocean rate of $38.27 per MT and the surface charges of $9.65 per MT, which were combined for the movement from Oswego, N.Y., to Port Elizabeth, N.J., and the overseas surface movement from Rotterdam to one of the commissaries in the Frankfurt area. The rate factors for the California movements as shown in table 8 were $38.27 per MT for the ocean movement and $37.55 per MT for the surface movements both in the United States and Europe.

The ocean rates the carriers offered the Government in 1970 and 1972 for this movement were special commodity rates which they filed in their tariffs for this traffic. These ocean rates were somewhat lower than the prevailing commercial ocean rates. This reduction was made because of the large volume of cargo involved and because they were Government shipments.

Table 8.--Surface transport charges for shipping lettuce in van containers from U.S. growing areas to final destination in West Germany, 1970

Lettuce growing area	Freight rate per measurement ton 1/		
	U.S. surface	Ocean	Overseas surface
	Dollars	*Dollars*	*Dollars*
Oswego, N.Y.	6.10	38.27	3.55
Salinas, Calif.	34.00	38.27	3.55

1/ Rates based on minimum 42.65 MT per van container.

Overseas Surface

The overseas surface charge for transportation from Rotterdam, The Netherlands, to Kaiserslautern, West Germany, was for movement of the van containers by container train. The ocean carrier added this charge to the others and offered the Government a single rate for the total movement, which was actually a combination of three separate charges (U.S. surface, ocean, overseas surface). The overseas surface charge for the 1970 shipments was $3.55 per MT, based on 42.65 MT per 35-foot unit van container; while that for the 1972 shipments was $3.37 per MT, based on 48.85 MT per 40-foot unit van container.

The van containers were carried on flat cars of the container trains, two containers to a car. Each flat car carried a diesel-powered motor generator which provided power for the refrigeration units of the van containers.

Air

The air rates charged by the carriers from New York and California were not the regularly published commercial rates, but rate tenders filed by the carrier to provide for through-bill service. The through-bill service of the air carrier began at the U.S. airport and ended at Kaiserslautern. The charges from the overseas airport to the final destination were added to the air carrier's bill-of-lading.

Table 9 shows the 1970 transport charges for the movement of the lettuce by air from origin to destination. The air charges and the overseas surface charges were listed as separate items on one Government bill-of-lading. The U.S. surface charges were submited by the carrier on a separate bill-of-lading with no identification of the air movement.

Table 9.--Air transport charges for shipping lettuce from the United States to Kaiserslautern, West Germany, 1970

Lettuce growing area	Freight rate per hundred pounds		
	U.S. surface	Ocean	Overseas surface
	Dollars	*Dollars*	*Dollars*
Oswego, N.Y.	1.75	20.00	3.58
Salinas, Calif.	0.59	25.00	3.58

The charges for the air shipments from California were, on the average, 9 cents per pound higher in 1970 than in 1972--the average surface transport charge at destination in 1970 being 5.5 cents a pound and only 0.5 cents a pound in 1972.11/

11/ The rates for the air shipments were specific commodity rates filed by the carrier in his tariff at the request of the Government. The rate from San Francisco, Calif., to Frankfurt, West Germany, was 25.3 cents a pound with 3,000 pounds minimum weight per shipment. The rate from New York to Frankfurt was 20 cents a pound with 3,000 pounds minimum.

The higher transport charges for the air shipments in 1970 were predicated on the use of a smaller plane, the Boeing 707, and a larger container, the Type A-2 igloo (fig. 3A). In 1972, a much larger plane, the Boeing 747, was used with LD-3 containers (fig. 3B). The lower rates in 1972 could be justified by the increased cargo capacity of the Boeing 747.12/

The Type A-2 igloos are containers used primarily in Boeing 707 airplanes with 10,000 pounds maximum gross weight and 350 cubic feet. The LD-3 cargo loaders are generally stored in the bellies of Boeing 747 jumbo jets with 2,500 pounds maximum payload and 153 cubic feet usable volume.13/

The cost differential for the California air shipments of 19.1 cents a pound in 1970 (table 5), 10.2 cents a pound in 1972 (table 6), and 57.45 cents in 1976 (table 7) in favor of the air shipments raised the question of the cost effectiveness of the air transport in the movement of lettuce overseas. The Department of Defense's transportation personnel 14/ made tentative cost computations which indicated that approximately 35 percent of the lettuce shipped by surface mode could be lost before the air shipments would be cost effective.

Spoilage losses helped determine the cost effectiveness of the respective modes of transport. Spoilage losses of 5 to 6 percent sustained by surface transport of lettuce during the 6-month test period affirmed the cost effectiveness of containerized surface transport in movement of lettuce overseas.

INTERMODAL MOVEMENT 15/

The extent of intermodal movement of the van containers during this test period was significant to this research. The 1970 surface test shipments were completely intermodal from origin to destination. Each shipment was handled at the ports of origin and destination only. All intermodal handling was eliminated, thus reducing incidence of damage or loss. The van containers were loaded in the field and trucked by refrigerated highway trailer to the port of

12/ Test shipments in 1970 were carried in all-cargo Boeing 707's with 90,000 pounds capacity, or 7,550 cubic feet. The test shipments in 1972 were carried in the bellies of 747's which also carried a maximum of 342 passengers These combination passenger and cargo 747's have a cargo capacity of 40,000 pounds, or 3,340 cubic feet.

13/ Carriers offer container discounts when a shipper uses standard-size containers registered with IATA (International Air Transport Association). The discounts offered vary with the size of the container and cannot exceed 10 percent of the freight charge. The container discount or rebate allowed for a Type A-2 igloo amounts to $105.60.

14/ Cody, J. P. Test program--transportation of lettuce to Europe. Audit Report No. WE72-212, March 24, 1972, CAAA-WED-A.

15/ The transfer and movement of the van container from one mode of transport to another during transit from origin to destination.

embarkation, where they were loaded aboard the containership. At the overseas ports, the van containers were pulled by trucks or, in most cases, loaded onto the container trains and transported to their final destinations in West Germany. The 1972 surface shipments were containerized at the port of embarkation in Virginia after being transported by truck from California.

At the U.S. port, the loaded van containers were loaded aboard the containership. At the overseas ports the van containers were unloaded from the containerships and transported by container trains to their destination.

Although the 1970 surface shipments were intermodal from origin to destination, delays were encountered at the ports. The shipments were, at times, held over at the port of embarkation because there were no refrigerated spaces available on the containerships.

During the 1970 and 1972 test shipments, there was a continuous shortage of refrigerated van containers among all the ocean carriers. Shippers encountered difficulties in obtaining refrigerated van containers in time for their scheduled shipping dates.

Both the ocean carriers involved in the 1970 and 1972 test shipments encouraged the intermodal movement of the cargo through the interchange of van containers and chassis with rail and motor carriers. Interchange agreements permitted the surface carriers to use the van containers as if they were their own until they returned them.

Most of the overseas surface movement of the van containers from Rotterdam, The Netherlands, to Kaiserslautern, West Germany, was accomplished by Intercontainer trains.16/ The intermodal movement of the containers by rail was expeditious. The containers moved on specialized trains from Rotterdam to Kaiserslautern. This was a route with regular, large-volume movements, not subject to shunting, which resulted in considerably reduced transit time. The all-container trains departed Rotterdam at 11:00 p.m., and arrived in Kaiserslautern at 7:00 a.m. Because these shipments were subject to temperature control, the planning and movement of all the test shipments were executed by Interfrigo.17/

Another unique feature of this intermodal movement of the van containers from the port of embarkation in Rotterdam to the Cold Storage Facility in Kaiserslautern was the movement across international boundaries from The Netherlands to West Germany with no customs inspections of the containers until final destination.

16/ An international body comprised of 19 European national railways that launched the development of container movements in through trains across national boundaries.

17/ An association of 19 European national railways whose aim is the optimum utilization of the available stock of refrigerated rail cars or refrigerated van containers for carrying perishable merchandise in international traffic.

This unobstructed movement of the container across national boundaries was made possible by the Transports International des Routier (TIR) carnet system which allows prior certification of the carrier's van container.18/ TIR was an important factor in the expeditious movement of the container to its destination and was responsible for eliminating at least a day's delay for customs inspection at The Netherlands-West German border.

The documentation necessary for movement of the lettuce shipments was simplified because of the TIR carnet. No additional documentation was necessary when TIR container trains crossed the borders of The Netherlands-West Germany. Neither were customs forms required nor import duties levied under this TIR carnet system until the shipment arrived at its final destination.19/

The air shipments encountered some difficulties in movement by different transport modes. Neither the LD-3 container nor the Type A-2 igloo used in these tests was source-loaded. The shipments were brought to the airport by refrigerated trailer trucks and loaded into the containers. The possibility of bringing the empty containers to the field for loading was considered; however, the idea was discarded because of the handling and transport difficulties.

The air containers (Type A-2 igloo or LD-3) were unloaded at the overseas airport because of the difficulty of transporting them to their final destination. The Type A-2 igloo, because of its irregular configuration and weight, required mechanical cargo lifting equipment to handle, load, or unload. The air shipments, therefore, had to be unloaded from the air containers into the delivery trucks at the airport for movement to final destination.

The lack of adequate cold storage facilities at the airports was a serious problem. When the lettuce shipments missed their plane connections, the loaded Type A-2 igloos or the LD-3 containers sat for many hours without refrigeration at the airport awaiting the next plane.

DISCUSSION

Data collected and observations made during the experimental tests provided significant evidence that under proper conditions the shipping of good lettuce by surface transportation to overseas markets in good condition and at a reasonable cost is feasible.

18/ Transports International des Routier. Road transport operating agreements reached by European governments for the international movement of goods by road. Permits sealed loads to cross national frontiers without inspection or tariff penalties.

19/ The ocean carrier became a member of the TIR carnet system by applying for coverage of its containers to an issuing agent. When its application was approved and the required bond had been posted, a TIR carnet was issued for all of the carrier's containers moving cargo in the 24 European countries which were members of this sytem. There were no import duties levied on this shipment because this was a noncommercial military shipment for troop issue.

The van container was an improved method over the break-bulk system for transporting lettuce overseas, especially when the van container was loaded in the field and unloaded at the receiver's warehouse. The use of the van container reduced the number of times the lettuce boxes were handled in transit, thus reducing the box and product damage.

The average ocean transit times of the containerships were poor; however, they were an improvement over the average transit times of the conventional break-bulk cargo ships. The slow transit times were due to antiquated containerships, problems in scheduling of ships, mechanical difficulties, and documentation problems.

Transit times did not present a problem for air shipments; however, poor scheduling and the lack of sufficient refrigerated facilities at the airports hindered the expeditious movement of these lettuce shipments. Transit times were more critical for the air than for the surface shipments, because air shipments during transit frequently were not under refrigeration. For instance, the only time the shipments were under refrigeration was in movement from the field to the airport. Once the shipments reached the airport, in most cases they were transported to the final destination without refrigeration. Under these conditions, any delay in transit had a serious effect on the shelf life of the lettuce.

A serious problem experienced with the air shipments was the difficulty in transporting the empty air cargo containers (LD-3 and Type A-2 igloo) to the field for loading and returning the loaded containers to the airport. Similar problems were experienced at the overseas airport. At the airport, cargo containers were unloaded and the lettuce boxes loaded into delivery trucks which made delivery to the consignee. Had the air cargo containers been intermodal and accepted by truckers, transit times for the air shipments would have been greatly lessened.

With the recent faster and larger containerships replacing the antiquated ones, transit time for the surface shipments should improve considerably. However, even with this new equipment, scheduling problems and mechanical difficulties continue to exist. These difficulties were malfunction of mechanical refrigeration equipment and automatic temperature controls out of calibration. Therefore, significant improvement in transit times depends on the ability of the carriers to solve these problems.

Handling of the lettuce shipments varied between the various growers and between the different modes. In the 1970 test shipments from New York State, where the trimming, wrapping, and boxing were manually done in the field sheds, nine separate handlings of the lettuce and lettuce boxes were required from the time the lettuce was harvested until it was loaded into the van container for movement to the port. In the 1970 shipments from California, where the trimming, wrapping, and boxing were done mechanically, there were seven separate handlings.

In the 1972 California test shipments, lettuce was mechanically handled, transported to the port in a refrigerated trailer truck, and transferred into a van container at the port. This required three additional handlings, making a

total of 10 handlings from time of the harvest until the shipment was loaded into the van container at the port. The last three additional handlings were necessitated by a short supply of van containers which the carriers could not provide.

Load patterns were critically important to the good arrival condition of the lettuce. Before this study, either a solid stack or a conventional lengthwise air-flow pattern was normally used in overseas shipments of lettuce. This research showed that the bonded-block load pattern, superior to the conventional lengthwise load pattern, resulted in less spoilage losses.

The bonded-block pattern was found to allow air circulation through the load, thus promoting rapid, uniform cooling. On the basis of the static cooling tests, average pulp temperature of the lettuce loaded with the bonded-block pattern was found to be 5 degrees cooler (33.1° F) than that of lettuce loaded with the conventional lengthwise pattern (38.6°). Spoilage data collected by the Department of the Army indicated average losses ranged from 5.8 to 6.7 percent when the bonded-block pattern was used and ranged from 20 to 25 percent when the conventional lengthwise load pattern was used.

Containerization of lettuce is necessary because lettuce is subject to bruise damage and rapid decay in transit. The use of the van container linked the lettuce grower with the ultimate consumer by eliminating as many as 10 separate handlings, minimized cargo loss or damage, hastened delivery, and reduced overall costs. Furthermore, containerization in both the air and surface test shipments speeded the movement of lettuce from the growers to the overseas customer. This produced inventory savings, eliminated intermediate handling, and simplified documentation.

The surface test shipments were truly intermodal and were readily coordinated within the transport system by refrigerated trucks in the United States and primarily by Intercontainer trains in Europe. In the 1970 test shipments, the ideal containerization procedure prevailed when containerization took place at the point of origin. Under this procedure, costly intermediate handlings were avoided and the containerized lettuce shipments moved directly to the receiver. In the 1972 test shipments, containerizations at the port of embarkation were subject to more handlings and transport hazards. The shipments were denied the full benefits of containerization in the movement from the point of origin to the port.

Most of the shipments in the 1970 and 1972 test shipments benefited from the surface movement in Europe by means of the Intercontainer, the international container trains. This particular movement was a classic example of intermodal movement at its best; the least costly movement and the fastest and most efficient mode available.

Although the air shipments were containerized, most of the advantages of containerization were dissipated because the containers (the Type A-2 igloo and LD-3) used in the air shipments were not intermodal. The containers were loaded at the U.S. airports and unloaded at the overseas airports, thus subjecting the shipments to a number of handlings. Because these airline containers were designed to utilize the contoured space of the aircraft, they could not be transported by truck at a reasonable cost.

The transport cost figures developed for 1976 continue to show great cost differences between surface and air shipments. Although the effects of the energy crisis and inflation more seriously affected the air rates than the surface charges, all transport charges were increasing, nevertheless, at an alarming rate.

CONCLUSIONS

Based on the data collected and the observations made, researchers concluded that the most feasible and least costly method of transport of lettuce to European markets is containerization. This containerization should be completely intermodal and one that originates in the field and terminates at the receiver's warehouse. The van containers used in these test shipments kept the box and lettuce damage to a minimum, speeded the lettuce shipments from the field to the consumer, reduced inventory costs, simplified documentation, and minimized the number of handlings.

The refrigerated van container shows great promise for the safe movement of agricultural perishables to overseas markets at reasonable costs. The intermodal transfer of the van container provides a way for the safe and expeditious movement of the cargo from the shipping point to the receiver when properly used.

The bonded-block load pattern used to load the van container permitted the greatest air circulation in the container and lower pulp temperatures of the lettuce.

To deliver good lettuce at destination, the lettuce shipped must be free of any inherent defects. If the lettuce was good at the time of harvest and bruise damage in transit was minimized by use of the van container, the arrival condition of the lettuce was good.

The outturn of the lettuce at destination was best and the transportation cost lowest when the following conditions were met:

- The quality of the lettuce shipped was good and the mechanical refrigeration equipment on the van container was functioning properly.
- Intermodal transport from origin to destination was expedited.
- Care was taken in loading the containers.

This research effort indicates that current transport technology generally is adequate for the movement of agricultural perishables by surface transportation to overseas destination in good condition. With the proper attention to both the transport equipment and the commodity shipped, agricultural perishables can be shipped overseas at reasonable cost and in good condition.

With average spoilage losses of 5 to 6 percent sustained by the surface lettuce test shipments over the 6-month period, the cost differential of about 9.5 cents per pound between air and surface transport verified the cost

effectiveness of containerized transport for the movement of lettuce overseas. Therefore, based on the data developed during this study, air transportation is warranted only when an emergency resupply situation exists.

This interdepartmental research was mutually beneficial to the Defense Supply Agency, the Department of the Army, and the U.S. Department of Agriculture. USDA's participation in these tests produced improvements in DSA's handling, loading, and transport procedures in moving lettuce to overseas bases for commissaries and troops. On the other hand, USDA had the opportunity to study various methods for delivery of U.S. lettuce overseas in a better condition and at a lower cost.